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## ABSTRACT

Evidence has mounted that science knowledge can be promoted by collaborative group work. Frequently, the benefits stem from the appropriation of insights that are collectively developed. However, benefits have also been observed that are independent of collective insights, and that sometime occurs in their absence. This presentation reports a study that examines whether such benefits stem from frameworks that emerge during group work but that trigger the productive use of later events. The study involved 8-to-12 year-old children working in foursomes on a task concerned with floating and sinking. 36 children (Condition A) viewed demonstrations 2, 4, and 6 weeks after the group task that had the potential to consolidate their collaborative experiences. The other 36 group participants (Condition C) did not witness the demonstrations. A further 36 children (Condition B) viewed the demonstration without the group task, and a final 36 children (Condition D) experienced neither the demonstration nor the group task. Condition A responded more productively to the demonstrations than Condition B, and their responses had more impact on knowledge growth. Growth was also higher in Condition A than in all other conditions. The results therefore strongly support the power of group work to trigger the productivity use of post-group experiences. (Contains 13 references.) (Author)

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# COLLABORATIVE GROUP WORK IN SCIENCE: INCUBATION AND THE GROWTH OF KNOWLEDGE

[Presentation to Biennial Meeting of Society for Research into Child Development,  
Tampa, Florida, April 2003]

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## Abstract

Evidence has mounted that science knowledge can be promoted by collaborative group work. Frequently, the benefits stem from the appropriation of insights that are collectively developed. However, benefits have also been observed that are independent of collective insights, and that sometimes occur in their absence. This presentation reports a study that examines whether such benefits stem from frameworks that emerge during group work, but that trigger the productive use of later events. The study involved 8- to 12-year-old children working in foursomes on a task concerned with floating and sinking. 36 children (Condition A) viewed demonstrations 2, 4 and 6 weeks after the group task that had the potential to consolidate their collaborative experiences. The other 36 group participants (Condition C) did not witness the demonstrations. A further 36 children (Condition B) viewed the demonstrations without the group task, and a final 36 children (Condition D) experienced neither the demonstrations nor the group task. Condition A responded more productively to the demonstrations than Condition B, and their responses had more impact on knowledge growth. Growth was also higher in Condition A than in all other conditions. The results therefore strongly support the power of group work to trigger the productive use of post-group experiences.

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## Introduction

There is considerable evidence that science knowledge can be promoted by collaborative group work between children (Howe et al., 1995; Howe & Tolmie, 1998), but little is known about the mechanisms by which children learn from collaborative experiences.

One popular account sees children as constructing collective insights that are superior to their starting points, and that are then individually appropriated (Rogoff, 1990; Vygotsky, 1978). While appropriation undoubtedly operates on occasion (Howe et al., 1992a; Williams & Tolmie, 2000), it cannot account for growth that is stimulated by group work, but occurs despite collective views that are:

- Inferior to individual starting points (Howe et al., 1992b);
- Unrelated to patterns of change (Howe et al., 1990, 1992b).

When post-collaborative growth occurs independently of collective insights, it is not typically apparent for several weeks (Howe et al., 1992b; Tolmie et al., 1993). It also depends on individual cognition, rather than follow-up experiences that are socially mediated (Howe et al., 1992b). It is therefore a manifestation of the well-known 'incubation phenomenon' (Yaniv & Meyer, 1987), even though incubation has seldom been explored in collaborative contexts.

Recent work by the author has examined the relevance of explanations proposed for incubation to group work in science. Two have been found to be irrelevant:

- Set breaking - Perhaps collaborative group work can lead children to 'fixate' on unhelpful ideas which they need an interval to move away from. However, even the strongest fixations are broken within hours of group work, and they exert no influence thereafter. They cannot explain why intervals of several weeks are required;
- Private work - Perhaps group work can stimulate productive post-group appraisal of collaboratively generated ideas. However, appraisal after group work is no more effective than appraisal in its absence.

This presentation focuses on a third possible explanation derived from the incubation literature (Seifert et al., 1995; Yaniv & Meyer, 1987): group work in science can result in frameworks which help children make productive use of subsequent experiences.

### **Rationale**

A study was conducted concerned with understanding of the factors relevant to floating and sinking. There were four conditions:

- Condition A - Individual pre-test; Collaborative group task; Demonstrations of potentially relevant material; Individual post-test;
- Condition B - Individual pre-test; Demonstrations of potentially relevant material; Individual post-test;
- Condition C - Individual pre-test; Collaborative group task; Individual post-test;
- Condition D - Individual pre-test; Individual post-test.

If group work can result in frameworks which allow productive use of experience:

- Condition A should respond more productively to the demonstrations than Condition B;
- Responses to the demonstrations should be more strongly associated with pre- to post-test change in Condition A than in Condition B.
- Pre- to post-test change in Condition A should surpass that in all other conditions.

### **Method**

#### **Pre-test**

The pre-test sample comprised 48 children from Primary Five classes (aged 8;4 to 10;5, mean = 9;5); 50 children from Primary Six classes (aged 9;1 to 11;1, mean = 10;3); 46

children from Primary Seven classes (aged 10;8 to 12;1, mean = 11;4). The pre-test was administered on a whole-class basis, with the children making written responses. No feedback was given on accuracy of responses.

The pre-test involved:

- Predicting whether each of six objects, e.g. wooden ball, plastic comb, metal spoon, would float or sink in a tank of water, and giving explanations for predictions;
- Explaining why objects float or sink in six real-world contexts, e.g. ships floating on the sea, soap sinking in a bath, ice cubes floating in orange juice.

Pre-test responses were scored, with inter-judge reliability checks on 25% samples:

- Factor Total (FT) - Total number of distinct factors mentioned in each explanation (inter-judge agreement = 97%), e.g. 'sinks because it's metal and heavy' -> FT = 2;
- Total Relevant (TR) - Total number of relevant factors in each explanation (inter-judge agreement = 100%), e.g. 'sinks because it's metal and heavy' -> TR = 1;
- Conceptual Level (CL) - Score given to 'best' factor in each explanation, on 0-4 scale (inter-judge agreement = 95%): a) Non-physical (0), e.g. 'meant to float'; b) Irrelevant physical (1), e.g. 'sinks because it's got bones'; c) Unco-ordinated relevant (2), e.g. 'sinks because it's heavy'; d) Co-ordinated relevant (3), e.g. 'floats because it's light for its size'; e) Co-ordinated object-fluid density (4), e.g. 'sinks because it's heavier than the same amount of water'.

### **Collaborative Task**

Six groups of four were formed at random from each age cohort, with each group undertaking the collaborative task about one week after the pre-test. Audio-recordings were made. The task involved:

- Each group member making independent predictions by writing on cards as to whether the objects in six sets (three objects per set, e.g. metal box, bottle of water, wooden ball) would float or sink in a tank of water;

- Group members: a) sharing independent predictions for each set in turn; b) reaching consensual predictions; c) testing consensual predictions by immersion in the tank; d) making joint interpretations of outcome; e) discussing real-world scenarios.

## **Demonstrations**

Two children from each group (N = 36) were assigned at random to view the demonstrations (Condition A). Further pre-tested children (N = 36, age equivalents of Condition A) who had not experienced the group task were also assigned at random to view the demonstrations (Condition B). All Condition A and B children from each school class in turn viewed the demonstrations together (N = c.12 per group).

The demonstrations were presented fortnightly after the group task:

- Demonstration 1 - Pairs of objects varying in weight, with other relevant features held constant, e.g. two identical plastic boats, one empty and the other loaded with coins; a matchstick and a nail of identical size. Children, working independently and responding in writing, made predictions about floating and sinking prior to immersion, and recorded and interpreted outcomes;
- Demonstration 2 - Pairs of objects varying in size, with other relevant features held constant, e.g. large and small wooden cubes of identical weight; two identical tinfoil squares, one open and the other folded in four. Task as Demonstration 1.
- Demonstration 3 - Triads of objects (real and cartoon) varying in weight and size, e.g. large heavy, small heavy, and small light cylinders. Task as Demonstration 1, but predictions (and explanations for predictions) only for cartoon objects.

Explanations given to each pair/triad were awarded FT, TR and CL scores as above. In addition, a count was made of the number of pairs/triads on which weight (W score) and size (S score) were used correctly. Inter-judge agreement over 25% samples = 97% (FT), 99% (TR), 98% (CL), 100% (W), 99% (S).

## Post-test

Condition A (less one absentee), Condition B, Condition C (the remaining group members,  $N = 36$ ), and Condition D (pre-tested children who had not experienced the group task or the demonstrations,  $N = 36$ ) were post-tested eight weeks after the group task. Post-test format was equivalent to pre-test, except that new items (of equivalent difficulty) were used. Presentation and scoring followed pre-test procedures.

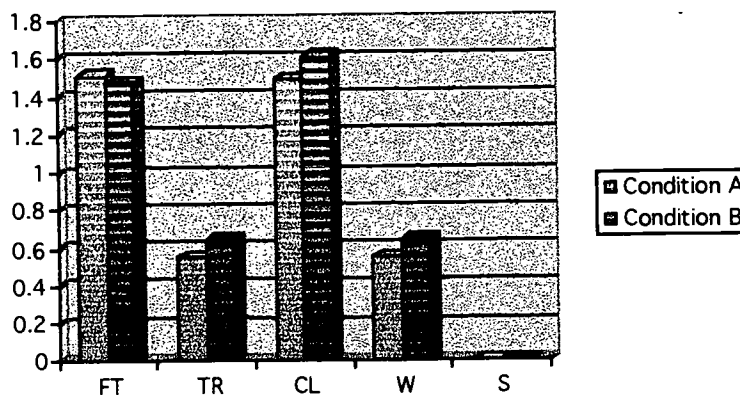
### Results 1: Condition A did respond more productively to the demonstrations

With each demonstration, mean FT, TR, CL, W and S scores across pairs/triads of objects were calculated for each child. Condition means were compared by t-test.

#### Demonstration 1

Most 8- to 12-year-olds expect light objects to float, and heavy objects to sink (Howe, 1998). Therefore, no differences between Conditions A and B were anticipated with Demonstration 1, and no significant differences were found (Figure 1):

Figure 1

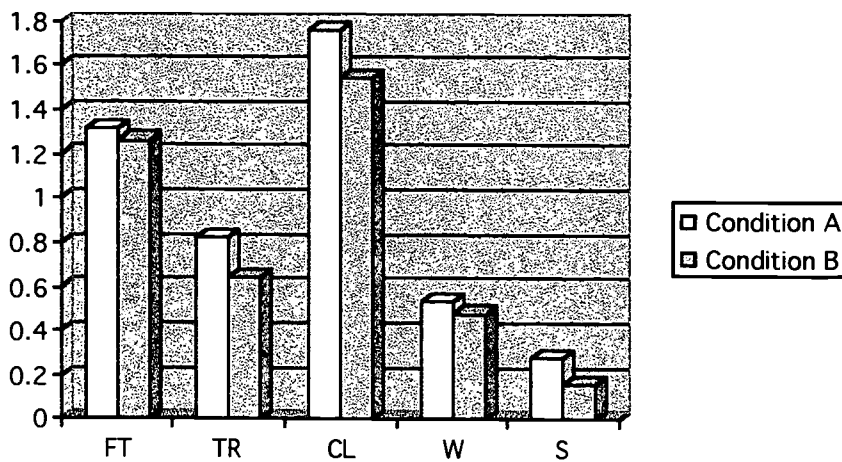


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### Demonstration 2

Few 8- to 12-year-old children appreciate the relevance of size, let alone understand that, all other things being equal, big objects are more likely to float than small (Howe, 1998). Condition A was therefore expected to exceed Condition B over TR, CL and S score, and (Figure 2) this is what happened (for TR,  $t(70) = 2.76, p < .01$ ; for CL,  $t(70) = 2.41, p < .05$ ; for S,  $t(70) = 2.34, p < .05$ ). As a measure of productivity rather than understanding, no condition differences were expected with FT, and no differences were found ( $t(70) = .47, ns$ ). Concerned with a factor that is well-understood, no differences were expected or found with W ( $t(70) = .87, ns$ ).

Figure 2

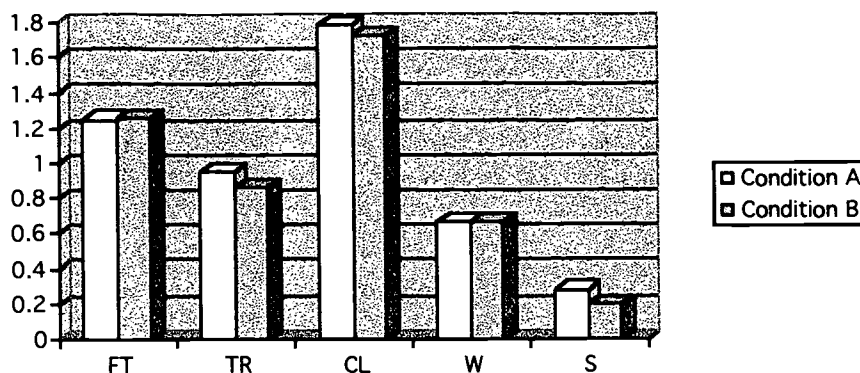


### Demonstration 3

The results with Demonstration 3 were expected to show the same pattern as with Demonstration 2, and this was discernible (Figure 3). However none of the differences proved statistically significant (for FT,  $t(70) = .05, ns$ ; for TR,  $t(70) = .88, ns$ ; for CL  $t(70) = .42, ns$ ; for W,  $t(70) = .003, ns$ ; for S,  $t(70) = 1.32, ns$ ).

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**Results 2: Response to the demonstrations were more strongly associated with pre- to post-test change in Condition A**

Subtracting pre-test FT, TR and CL scores from post-test FT, TR and CL scores to produce measures of change:

- In Condition A, FT change was significantly correlated with FT score in Demonstration 3 ( $r(33) = .61, p < .001$ ); TR change was significantly correlated with TR score in Demonstration 3 ( $r(33) = .35, p < .05$ ); CL change was significantly correlated with CL score in Demonstration 3 ( $r(33) = .38, p < .05$ ).
- In Condition B, FT change was significantly correlated with FT score in Demonstration 3 ( $r(34) = .34, p < .05$ ), but TR and CL change were not associated with Demonstration 3 TR and CL scores.
- In Condition A, there were strong correlations between performance in Demonstration 2 and Demonstration 3. These correlations were not observed with Condition B.

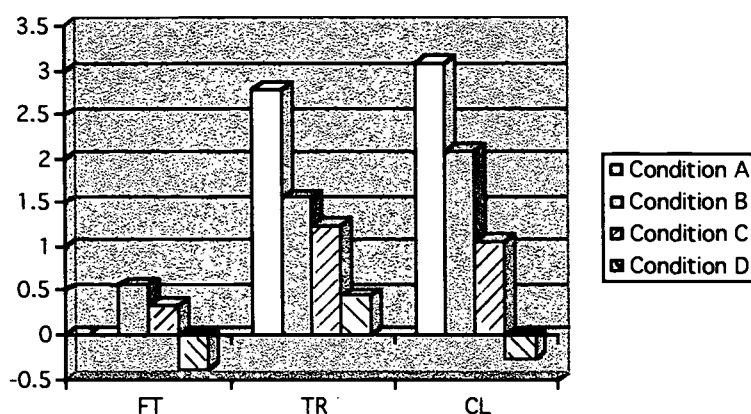
It can be concluded that the strong performance that Condition A produced during Demonstration 2 was sustained through to Demonstration 3, and beyond this to post-test. The performance that Condition B produced during Demonstration 2 was relatively weak, and its consequences were less pronounced.

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### Results 3: Condition A did surpass all other conditions over pre- to post-test change

There were no differences between the conditions at pre-test. There were also no differences between the conditions over pre- to post-test FT change ( $F(3,139) = .42, ns$ ). However, there were marked differences (Figure 4) over pre- to post-test TR and CL change (for TR,  $F(3,139) = 3.18, p < .05$ ; for CL,  $F(3,139) = 4.33, p < .01$ ). Post hoc tests (Scheffé  $p < .05$ ) showed that change in Condition A was significantly greater than in Conditions B, C and D, and change in Conditions B and C was significantly greater than in Condition D. Conditions B and C did not differ.

Figure 4



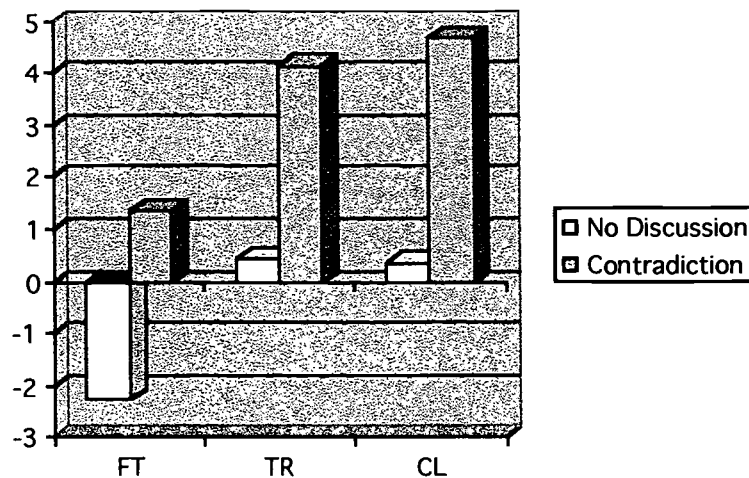
### Results 4: Contradiction may be critical

Condition A responded productively to the demonstrations, and their productive responses helped them learn. This is exactly what would be expected if group work has the capacity to provide frameworks for making good sense of subsequent experiences. However, what form do the frameworks take?

Since responses to Demonstration 2 (which focused on size) were pivotal, audio-recordings were analysed to explore how size was referred to during the group task:

- With six recordings, size was never mentioned once;
- With the other twelve, it was mentioned between 2 and 13 times (mean = 6.00), but invariably in a fashion that involved unresolved contradiction, i.e. small size would be associated with floating at one point and with sinking at another, without recognition, let alone resolution, of the conflict.

Figure 5



There were no significant differences (Figure 5) between the Condition A children who experienced the two types of discussion over FT change ( $t(33) = 2.00$ ,  $ns$ ), but considerably more TR and CL change after contradictory discussion (for TR,  $t(33) = 3.26$ ,  $p < .01$ ; for CL,  $t(33) = 2.49$ ,  $p < .05$ ). This suggests that recollection of unresolved contradiction may have underpinned the productive responses.

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## Discussion and Conclusions

The results strongly suggest that collaborative group work can lead to frameworks, which facilitate the productive use of subsequent events. It seems likely therefore that when group work triggers conceptual growth that is independent of collective insights, it is because these frameworks have been created.

The results also suggest that the frameworks are created when contradictory ideas are expressed, and the contradiction is not resolved on-task. Perhaps then collective insights are helpful when expressed (and agreed) ideas are not contradictory, or when contradiction is resolved. If so, learning from post-collaborative experiences and from collective insights are two sides of the same coin, with relationships within the dialogue determining which mechanism occurs.

Piaget (1985) recognised the importance of contradiction in conceptual growth, although neither he nor contemporary cognitive psychologists have considered the implications in detail. It is however clear that on Piaget's model, concrete operational functioning is required before contradiction can stimulate growth. This is consistent with the results in that the children, at 8 years and older, were likely to be functioning at the concrete operational level. There were no developmental trends in the data.

On the other hand, younger children should not be able to access mechanisms that rest upon contradiction. Therefore, if the present argument is correct, they should not be able to utilise frameworks, which facilitate the productive use of subsequent experience. They should be restricted to learning from collective insights. Exploring this would provide a powerful test of the current proposal, and could be a significant avenue for future research.

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